

CLAIMS

1. A magnetic memory device, including a plurality of magnetoresistive devices each including a magnetic sensitive layer of which the magnetization direction changes by an external magnetic field, wherein one storage cell includes a pair of the magnetoresistive devices, the magnetic memory device comprising:

a read line pair supplying a read current to the pair of magnetoresistive devices; and

a sense amplifier circuit reading information from the storage cell on the basis of a difference between a pair of read currents flowing through the read line pair,

wherein the sense amplifier circuit includes:

a differential switch pair being disposed for each read line pair;

a bias resistor pair being disposed between each differential switch pair and a power source; and

a constant current circuit being shared among a plurality of the differential switch pairs, and making the sum of a pair of read currents flowing through each differential switch pair constant.

2. A magnetic memory device according to claim 1, further comprising:

a current-voltage conversion resistor pair between the read

line pair and the power source,

wherein terminals of the current-voltage conversion resistor pair on a side opposite to a side closer to the power source are connected to the differential switch pair of the sense amplifier circuit.

3. A magnetic memory device according to claim 1, further comprising:

a first switch being disposed between each of a plurality of the differential switch pairs and the constant current circuit, and selecting one among the plurality of differential switch pairs; and

a pair of second switches being disposed between the power source and the read line pair, and selecting whether or not to supply a read current to the read line pair or not.

4. A magnetic memory device according to claim 3, wherein switching of the first and the second switches is controlled according to a first selection signal for selecting one among the plurality of differential switch pairs.

5. A magnetic memory device according to claim 3, wherein switching of the first switch is controlled by a first selection signal for selecting one among the plurality of differential switch pairs and a second selection signal indicating a read mode, and

switching of the second switches is controlled by the first selection signal.

6. A magnetic memory device according to claim 1, wherein the constant current circuit uses a bandgap reference.
7. A magnetic memory device according to claim 6, wherein the constant current circuit includes:
 - a current limiting transistor;
 - a diode being connected between the base of the current limiting transistor and the ground; and
 - a current controlling resistor being connected between the emitter of the current limiting transistor and the ground.
8. A magnetic memory device according to claim 1, wherein the bias resistor pair is also shared among a plurality of the differential switch pairs.
9. A magnetic memory device according to claim 3, wherein the pair of second switches, the current-voltage conversion resistor pair and the differential switch pair are packed in the same region.
10. A magnetic memory device according to claim 9, wherein

the pair of second switches, the current-voltage conversion resistor pair and the differential switch pair each have a symmetric circuit structure.

11. A magnetic memory device according to claim 1, further comprising:

a plurality of first write lines; and

a plurality of second write lines extending so as to intersect with the plurality of first write lines,

wherein each of the plurality of magnetoresistive devices includes:

a laminate which includes the magnetic sensitive layer and through which a current flows in a direction perpendicular to a laminate surface; and

a toroidal magnetic layer which is disposed on one surface of the laminate so that its direction along the laminate surface is its axial direction, and the first and the second write lines pass through the toroidal magnetic layer.

12. A magnetic memory device according to claim 1, wherein the magnetization directions of magnetic sensitive layers in the pair of magnetoresistive devices are changed by a magnetic field which is induced by currents flowing through the first and the second write lines so as to be antiparallel to each other, thereby

information is stored in the storage cell.

13. A sense amplifier circuit, being applied to a magnetic memory device, the magnetic memory device which includes a plurality of magnetoresistive devices each including a magnetic sensitive layer of which the magnetization direction changes by an external magnetic field, and a read line pair supplying a read current to a pair of magnetoresistive devices, wherein one storage cell includes a pair of the magnetoresistive devices, the sense amplifier circuit comprising:

a differential switch pair being disposed for each read line pair;

a bias resistor pair being disposed between each differential switch pair and a power source; and

a constant current circuit being shared among a plurality of the differential switch pairs,

wherein information is read from the storage cell on the basis of a difference between a pair of read currents flowing through the read line pair.

14. A method of reading from a magnetic memory device, being applied to a magnetic memory device, the magnetic memory device which includes a plurality of magnetoresistive devices each including a magnetic sensitive layer of which the magnetization

direction changes by an external magnetic field, and a read line pair supplying a read current to a pair of the magnetoresistive devices, wherein one storage cell includes a pair of the magnetoresistive devices,

the method comprising the steps of:

arranging a differential switch pair for each read line pair;

arranging a bias resistor pair between each differential switch pair and a power source;

arranging a constant current circuit so as to be shared among a plurality of differential switch pairs; and

reading information from the storage cell on the basis of a difference between a pair of read currents flowing through the read line pair.